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Generalization of Paired-Associate Learning and Concept Formation

Ronald H. Combs

Fort Hays Kansas State College

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GENERALIZATION OF PAIRED-ASSOCIATE
LEARNING AND CONCEPT FORMATION

Being
A thesis
Presented to
The Faculty of the Graduate School
Fort Hays Kansas State College

In Partial Fulfillment
of the Requirements for the Degree
Master of Science

by
Ronald H. Combs
Fort Hays Kansas State College

Date May 12, 1960

Approved *R. C. Cole*

Major Professor

Ralph D. Cohn
Chairman, Graduate Council

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Generalization of Paired-Associate

Learning and Concept Formation

Ronald H. Combs

Fort Hays Kansas State College

Is the generalization which results from procedures which fit the definitional requirements of two different learning methods the same? This study was designed to answer this question. In order to experimentally examine this query, the generalization tendencies arising from paired-associate learning and concept formation were compared. Before this discussion can be presented, some basic terms should be defined. For the purposes of the present study, the terms concept, generalization, and similarity must be defined. Also, the definitional requirements of paired-associate learning and concept formation will be supplied to the reader.

Concept. The term "concept" is used to refer to a set of stimuli which are not identical and which are grouped together by the experimenter according to similarity among them or in terms of some specified partial identity among them. (Dick, 1958, p. 2)

Generalization. Generalization is the elicitation of a response by a stimulus which is not identical with any one stimulus involved in previous training, but is similar.

Similarity. Similarity refers to a specifiable relationship between different stimuli. The relationship can be specified in terms of the amount of variation which separates stimuli on a given dimension, and also in terms of their

relative position on that dimension. The dimensions involved may be psychological, logical, or physical.

Paired-associate learning. The paired-associate method involves presentation of pairs of items, as in vocabulary list, under instruction to learn to associate the two members of each pair so that, when the first is presented, the second can be recalled. (McGeoch and Irion, 1952, p. 15)

Concept formation. Concept formation refers to the acquisition of a specific response to a number of similar stimuli. For example, when Ss are presented a number of similar forms and are required to learn the same name for all the forms, a concept of those forms is being formed.

As was previously mentioned, the purpose of this study was to compare the generalization tendencies arising from paired-associate learning and concept formation. An apparent conflict exists in the literature pertaining to the present discussion. This conflict is between hypotheses derived from a physiological theory proposed by Hebb (1949) and offered by Dick (1958), and a suggestion presented by Underwood (1952). The following discussion will show that Hebb and Dick are at odds with Underwood's suggestion, and that the hypothesis in this study is in agreement with Hebb and Dick.

In an exposition on thinking, Underwood suggests that on at least stimulus generalization, there is a possibility of a rapprochement of conditioning, rote learning, and tasks which fall within the category of thinking. Underwood suggests that there is communality among all of the situations producing behavior changes which fit the definitional requirements of learning.

Underwood's comments suggest it might be expected that a group of subjects trained by a method which fits the definitional requirements

of paired-associate learning, may generalize similarly to a group of subjects that are trained by a method which fits the definitional requirements of concept formation. Thus, if the two groups mentioned above were trained to learning criteria by the two different methods and a generalization test administered to each group, we might expect the groups to be similar in respect to their generalization tendencies.

In a study by Dick, the hypothesis that conceptual generalization occurred more readily from training Ss on low similarity concepts than from training Ss on high similarity concepts was not upheld. Dick's stimuli were distortions of semi-random prototypes. They were obtained by projecting the prototypes on a rotated screen, and tracing the images of the prototypes on the screen. The stimuli for each concept were distorted tracings from a single prototype. Low similarity concepts represented a greater range of distortion than did the high similarity concepts. The stimuli to test generalization were formed by systematically moving the points on which the prototypes were drawn. In this study, Ss were equated on amount of training that was received on low similarity and high similarity concepts. When amount of learning was used as a criteria, however, a statistical analysis did not support the hypothesis.

Dick suggested that a physiological theory by Hebb may be interpreted as a theoretical basis for the hypothesis which was tested. Hebb proposed that objects are perceived by the activation of cortical cell assemblies. Familiarity with an object is achieved when the assembly being activated

in turn activates other assemblies which were formed by that object. The integrated complex of assemblies involved in the perception of a familiar form is the schema of that form.

Dick proposed that Hebb's theory can be extended to predict his hypothesis if it is assumed that a schema like that involved in the perception of a familiar form is involved in the perception of the instances of a concept after concept formation. If, after concept formation, S is to perceive a new stimulus which activates cell assemblies, it is possible that one or more of these assemblies may have elements which are common to those in the schema of the concept. Dick suggests that the assemblies formed in the low similarity schema would vary more than would the assemblies in the high similarity schema. Thus, it would appear that the likelihood of a cell assembly involved in the low similarity schema being activated by a new stimulus would be greater than for the assemblies in the high similarity schema. This can be concluded because it seems that a greater amount of variation would exist between the assemblies in the low similarity schema than would exist among the assemblies in the high similarity schema.

This may be shown more clearly by use of an example: It may be assumed that two schemas, which are produced by two similar instances of a concept, are each comprised of six assemblies. If these instances of a concept are of high similarity, it would seem possible that five of the assemblies involved in each would be common to both, and only two assemblies would be unique. Thus, there would be only seven possible assemblies of these two schemas which could become activated by

a new stimulus. However, if two schemas were produced by stimuli of low similarity, it would seem possible that only one of the assemblies involved in each would be common to both; and five would be unique for each. Thus, there would be eleven possible assemblies which could be activated by a new stimulus.

This interpretation would seem to support the hypothesis proposed by Dick since his groups were trained on stimuli which differed in similarity along a specified dimension. The low similarity group was trained on stimuli which varied more than the stimuli on which the high similarity group was trained, and it would then seem that the assemblies involved in the schema for the low similarity training would also vary more than the assemblies in the schema of the high similarity group. Then, following the above interpretation, it would appear that generalization should have been greater for the low similarity group than for the high similarity group.

As was mentioned previously, it appears that the hypothesis by Dick and Hebb's theory are at odds with the suggestion offered by Underwood relative to the characteristics of learning. Dick's hypothesis, which was not upheld experimentally, and Hebb's theory may be interpreted to suggest that the tendency to generalize from the training situation would be less for Ss trained by the paired-associate learning method than for those trained by the concept formation method. It would seem that concept formation resulting from the association of a number of stimuli of low similarity with a single response would invoke a greater number of different assemblies in the schema of the concept than would paired-associate learning in the schema of a stimulus. It would then be expected that the

generalization would be greater when learning has been invoked by the concept formation procedure than by the paired-associate conditions. Even though Dick's results failed to support his hypothesis, he suggested that a more direct test of the hypothesis would be necessary before it could be rejected. Underwood suggested that there appears to be a basis for rapprochement of various learning situations in stimulus generalization. This is in direct contrast to the hypothesis which Dick was testing, and also with Hebb's theory. No attempt was made in this study to support Hebb in relation to the cell assembly proposal, but his theory was used as a theoretical basis for the hypothesis and also to point up the disagreement which this study was designed to resolve. This disagreement is probably due to the sparseness of basic research available on this topic.

The purpose of the present study was to attempt to further test the hypothesis proposed by Dick, and also to examine the suggestion presented by Underwood. An attempt was made to examine the suggestion proposed by Underwood by comparing the generalization tendency of Ss trained by a method which fits the definitional requirements of paired-associate learning with the generalization tendency of Ss trained by a method which fits the definitional requirements of concept formation. In doing this, it was also felt that a more direct test may be made of Dick's hypothesis. The paired-associate group was considered to be trained on high similarity of concepts, since training was on one stimulus for each response. Thus, the similarity between the stimuli in this group was maximum. The concept formation group was trained on more than one instance of a stimuli for each response. Thus, the similarity between stimuli was less than the

maximum similarity in the paired-associate group. The groups in this study are then considered to be similar to Dick's concept formation groups.

The hypothesis for this study is that when two groups of Ss are equated on degree of learning, resulting from the paired-associate and concept formation procedures, generalization will be greater for the group which is trained by concept formation.

Method

Subjects

The Ss used in this study were forty male and female students at Fort Hays Kansas State College. The Ss were volunteers from beginning psychology classes at the college. They were randomly assigned to two groups of equal number, with twenty male and twenty female Ss in each group.

Stimuli

The stimuli were 35 random forms arranged in five sets of seven forms, which are shown in Figure 2. The forms in each set were similar, while all sets differed. Each set had a nonsense syllable name which was different from the names of all other sets. A set consisted of seven, eight-sided random forms. Each set was comprised of one prototype and six variations of that prototype. The deviations of the prototype which were used are as follows: 0 (prototype), +1, +2, +3, +4, +5, and -3. The 0 to 5 plus deviations were used in the concept formation training. The 0 deviation was used for the paired-associate training, and the -3 deviation was used for the test stimuli.

Each of the stimuli was constructed in the following general method, which is a variation of the method proposed by Attneave (1957), and also that used by Dick: The numbers 1 through 9 were assigned to the marginal coordinates of an 8 by 8 matrix. Eight pairs of numbers were selected from a table of random numbers according to the following rules: (A) Each of the eight numbers on a coordinate can be used only once. (B) The pairs of coordinate values must differ from other pairs by more than one integer on one of the coordinates. Thus, if one pair of values was 2 and 3, the pairs

of 1 and 2, 3 and 4, 1 and 4, and 3 and 2, must be rejected. Following these rules, the points for the coordinate values were more or less evenly distributed on the matrix and separated by at least two spaces.

To obtain a random form for use as a stimulus, the points found by the method described above were plotted on the 8 by 8 matrix. The points were then connected in such a way as to produce the minimum perimeter possible and still include all eight points. This method produced an eight-sided random form. This form served as a prototype of 0 deviation.

In order to distort the prototype by controlled dimensions, these points were moved through one-inch diagonals in semi-randomly determined quadrants by increasing all even numbers and decreasing all the odd numbers of the eight pairs of coordinate values to get a new set of points. These new points were then joined by straight lines in the same sequence as those making up the prototype, resulting in a form which will be considered to be +5 deviations from the prototype. The one-inch diagonals were divided into five equal divisions. Then, by plotting five points on these division points and joining them together in the same sequence as they were in the prototype, four new deviated forms were obtained. A total of six similar forms was then obtained, and each form was labeled.

The prototype was then distorted by decreasing all the even numbers and increasing all the odd numbers (the converse of the above procedure) of the original pairs of coordinate values which produced the prototype. These new points were also connected by straight lines in the same sequence as the prototype, producing a form which may be considered to be -5 deviations from the prototype. These diagonals were then divided into five equal divisions, using the same method as described above.

The above procedure sometimes produced forms of more than eight sides; when this occurred, the set was rejected and a new prototype and deviations developed. An example of one of the prototypes is shown in Figure 1, along with its deviations. The prototype is shown by the heavy lines; the dotted lines show the +5 deviation, and the light, solid lines depict the -3 deviation. The procedure described above was repeated five times to produce five prototypes and six deviations of each. The entire series of forms used is shown in Figure 2.

These forms were traced on white paper, and cutouts were made. The cutouts were photographed, along with the appropriate nonsense syllables, and mounted in 2" by 2" slides. On each slide, a form was located in the upper half and a nonsense syllable in the lower half.

The nonsense syllables were some of those used by Dick, which were taken from Glaze's list. The syllables used were taken from those which Glaze reported to be of zero association value. Five syllables were randomly selected and assigned to the five sets of prototypes and deviations. This resulted in a prototype and the deviations of that prototype, all having the same randomly assigned name. The nonsense syllables used are shown on the left of Figure 2.

Apparatus

The apparatus used was modeled after that used by Dick. It consisted of an automatic projector equipped with a timer, an external shutter driven by a stallable motor, and a Hunter lll-C timer to open and close the circuit to the motor. The shutter motor was in series with the normally closed circuit of the Hunter timer. The external shutter blocked the lower part of the slide's projection when the circuit to the shutter motor was closed. When the timer opened the same circuit, the shutter lowered to expose the entire slide.

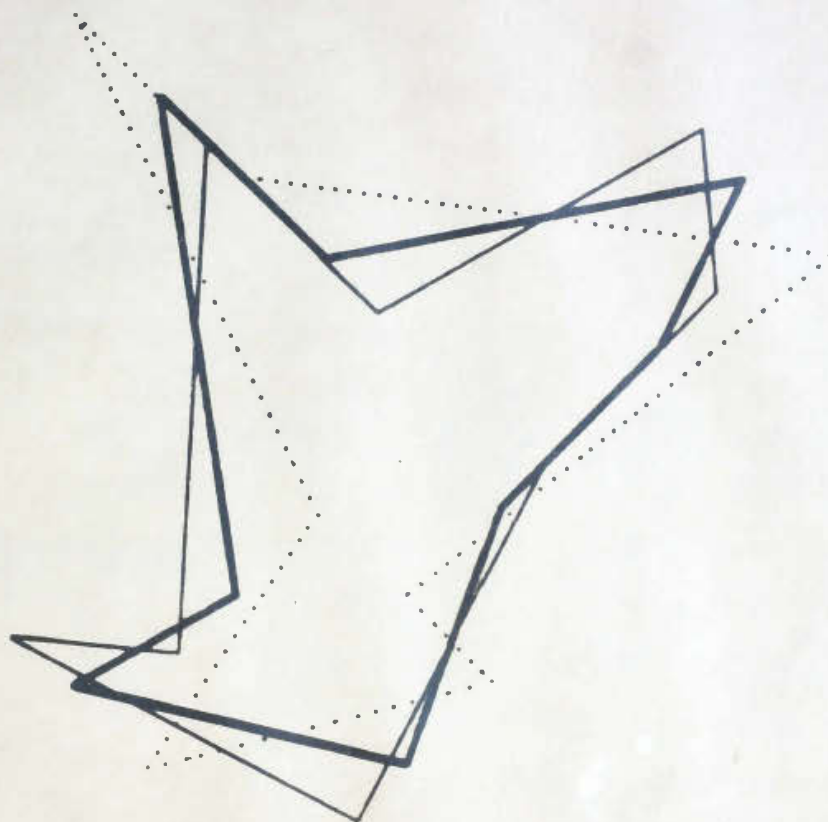


Fig. 1. Randomly generated forms.

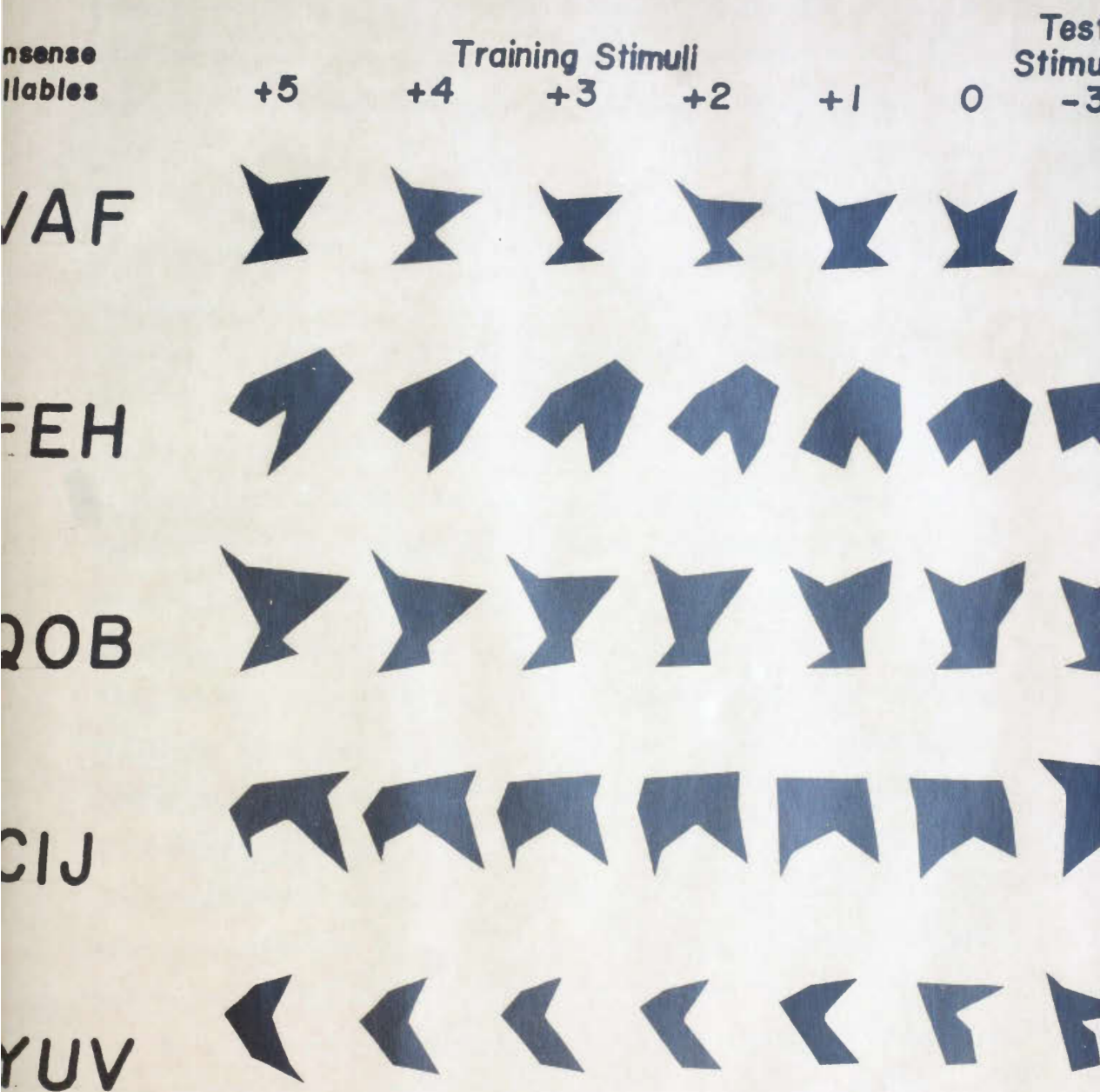


Fig.2. Randomly generated forms and the nonsense syllable names.

By arranging the apparatus in this manner, the upper part of the slides, which contains the forms, could be exposed and then followed by projection of the entire slide which introduced both the form and the nonsense syllable to S. The time interval for presentation of both the forms and the nonsense syllables could be controlled by the timers.

Procedure

Ss were trained by either the paired-associate or concept formation procedure to criteria. After training, all Ss were given the same generalization test.

The following procedure was used for all Ss: The five nonsense syllables, which were the names of the sets of forms, were displayed on a large card next to the screen. S was provided with a mimeographed sheet to record his responses. This sheet consisted of three columns of short lines. Each column included two short lines and numbers. The numbers represented the training trial for which the response listed and scored on that line represented. The numbers were arranged in numerical order from 1 to 30 on each sheet. Corresponding to each number were two lines. S recorded his response on the first line and scored that response on the second line. S placed a check on the second line if a mistake were made in anticipating the correct response to the form, or a plus if the correct response was made. If S failed to make a response before the shutter lowered and exposed the nonsense syllable, he scored the response as incorrect and the space for the response was left blank.

Each trial required ten seconds. The form was presented for the first seven seconds of the interval and the name was exposed with the form for the last three seconds of the interval.

S's task was to anticipate the nonsense syllable, which was the name of the form, by writing it on the response sheet before the name appeared on the screen. Each S was trained to a criteria of ten successive correct responses.

The training took place in a small classroom. E and S were the only occupants of the room, and the automation of the projector and timers allowed E to observe S throughout the training. E was seated behind and slightly to the side of S. This allowed E to stop the training procedure when S reached criteria (ten successive correct responses) and begin testing immediately.

The concept formation stimuli (0 to +5 deviations) were arranged in six random blocks for presentation. Each block consisted of five different forms. A single deviation of each of the five sets of stimuli was included in each block. The deviations of each set to be included in a given block were randomly determined.

The paired-associate stimuli (prototypes) were also arranged in six blocks for presentation. Each block consisted of all five prototypes (0 deviations). The arrangement of the prototypes in the paired-associate blocks was determined by the arrangement of the sets in the concept formation blocks. Thus, the order of the stimuli within the six paired-associate blocks was the same as the sets in the six concept formation blocks.

The stimuli were presented in the same order to all Ss in each group. The following general instructions were given to all Ss:

This is an experiment in generalization. You are asked to do as well as you can and to be completely honest during the presentation of this material.

You have received a sheet on which you are to record your answers. At this time, please fill out the information at the top of the page....You will notice that the answer sheet has two lines which correspond with each number. On the first line, you will write one of these nonsense syllables that are printed on this card. On the second line, you will either make a check or a plus, depending upon your answer. (A large reproduction of the answer sheet was drawn on a blackboard and used to emphasize each point.)

For those Ss who received training by the paired-associate method, the following additional instructions were given:

You are going to be shown a series of forms, one at a time. You are to learn a name for each of these forms. You will be shown each form for 7 seconds and then the name of the form will be shown to you for 3 seconds. Before the name appears, you must write the name that you think is correct on your answer sheet. You should guess if you are not sure of the correct name. If the name appears on the screen before you have written a name down, please make a check on the second line of the number which corresponds to that answer. If the name that you write down is not correct, make a check on the second line. If your answer is correct, mark a plus on the second line. Report aloud whether you received a plus or a minus on each trial as you score it. We will run through the forms once before the trials begin. Do not write anything on your answer sheet during this first presentation.

Concept formation instructions were the same as those administered to the paired-associate group with the following added: Each of the nonsense syllables will be the name for more than one form. The forms for which each name will be a correct response will have something in common in their appearance.

Before the first training trial for which Ss were to score their answers, they were encouraged to ask questions about any part of the instructions which were not clear. E explained any part of the instructions which were not understood.

The test consisted of presenting the five test stimuli (-3 deviations) in random order for 10 seconds each. Ss were asked to give the correct

name (nonsense syllable) for each form. Answer sheets, which consisted of 20 blank lines, were given Ss before instructions were presented. The nonsense syllables were not presented with the forms. Ss were instructed to record a response for each form even if they had to guess.

The test stimuli were presented to S four consecutive times in the same order. The cumulated number of correct responses were used as S's score on the generalization test. A correct response was defined as the writing down of the appropriate nonsense syllable when shown a given form. The appropriate nonsense syllable was the syllable which was randomly assigned to each set as the name of the similar forms in that set. These scores were interpreted as a measure of generalization tendency from the training procedures.

Before the test was administered, the first time only, the following instructions were read to all Ss:

You are now going to be tested on how well you have learned the forms that you have been studying. You will see another series of forms. These forms will be different from the ones you were trained on, but they will be similar to those that you have learned. Your task will be to write down the correct name for each form. You will see each form for 10 seconds. You will not see the name of the form. When the time is up, the next form will appear. Do not leave a blank space on your answer sheet; you must write a response for each of the forms. If you are not sure, take a good guess. Remember, the forms will not be exactly like any of the ones that you have seen before, but they are similar to them. Be sure to write a response for each form.

Treatment of data

As was described earlier, the S's score was computed by totaling the number of correct responses made to the test stimuli. Thus, S's score ranged from 0 to 20, since there were five stimuli in each of the four test series. A high score represented high generalization, and a

low score represented low generalization on the test. A one-tailed analysis of variance was used to analyze the data from the generalization test.

Results

The means and variances for the generalization scores are reported in Table 1. The results of the analysis of variance of this data with method and sex as main effects are reported in Table 2. A significant difference ($P < .025$) was found between learning methods. The difference is in favor of the concept formation group. This significance supports the stated hypothesis that when two groups of Ss are equated on degree of learning, resulting from the paired-associate and concept formation procedures, generalization will be greater for the group which is trained by concept formation. No significant difference was found between sexes or for the interaction of the main effects.

The means and variances for the number of trials needed for Ss to reach learning criteria are reported in Table 3. The results of the analysis of variance on the training data are reported in Table 4. A significant difference ($P < .001$) was found between the learning methods. The difference was expected since it was felt that learning of the concept formation stimuli would require a greater amount of training than would the learning of the paired-associate stimuli. No significant difference was found between sexes or for the interaction of the main effects.

Table 1

Means and Variances of Generalization Scores

Learning Methods

| Sex | Concept Formation | | Paired-associate | |
|--------|-----------------------|---------|-----------------------|-----------------------|
| | n | M | n | M _r |
| Male | n =10 | M =11.5 | n =10 | M =10.0 |
| | s ² =11.05 | | s ² =6.40 | M _r =12.25 |
| Female | n =10 | M =12.0 | n =10 | M =10.0 |
| | s ² =16.40 | | s ² =23.09 | M _r =11.15 |
| | M _c =13.25 | | M _c =10.45 | |

Table 2

Summary of Analysis of Variance on Generalization Scores

| Source of Variance | Σx^2 | d.f. | m.s. | F |
|--------------------|--------------|------|-------|--------|
| Between methods | 78.40 | 1 | 78.40 | 11.96* |
| Between sexes | 6.40 | 1 | 6.40 | .40 |
| Sex X Method | 28.90 | 1 | 28.90 | 1.83 |
| Within cells | 569.40 | 36 | 15.82 | |
| Total | 683.10 | 39 | | |

* $F < .025$

Table 3

Means and Variances of Training Trials to Criteria

Learning Methods

| Sex | Concept Formation | | Paired-associate | |
|--------|-------------------|-------------------------|------------------|-------------------------|
| | n | M | n | M _P |
| Male | 10 | 122.7 | 10 | 86.4 |
| | | s ² =3580.61 | | s ² =1307.41 |
| | | | | M _P =104.55 |
| Female | 10 | 159.8 | 10 | 59.2 |
| | | s ² =4047.36 | | s ² =527.16 |
| | | M _C =141.25 | | M _C =72.80 |

Table 1

Summary of Analysis of Variance on Training Data

| Source of Variance | Σx^2 | d.f. | m.s. | F |
|--------------------|--------------|------|----------|--------|
| Between methods | 16851.03 | 1 | 16851.03 | 17.83* |
| Between sexes | 215.03 | 1 | 215.03 | .09 |
| Method X Sex | 10336.22 | 1 | 10336.22 | 3.93 |
| Within cells | 94625.70 | 36 | 2628.19 | |
| Total | 152060.98 | 39 | | |

* $P < .001$

Discussion and Conclusion

This experiment was designed to test a hypothesis proposed by Dick, and also, to examine a suggestion presented by Underwood.

Dick's hypothesis was that generalization occurred more readily from training Ss on low similarity concepts than from training Ss on high similarity concepts. It is felt that the method used in this study provides a more adequate test of the hypothesis than did the method used by Dick. In that study, the hypothesis was tested by comparing the generalization tendencies resulting from training on stimuli which differed in amount of similarity. Both low and high similarity stimuli were varied along a similarity continuum in the same direction but by different amounts.

In the present study, the paired-associate and the concept formation groups also differed in the similarity between the stimuli. The paired-associate group was trained on a single stimulus for each response. Thus, the similarity must be considered maximum. The concept formation group was trained on several similar stimuli for each response; therefore, the similarity between the stimuli of this group was less than the maximum similarity in the paired-associate group. It then seems that the primary advantage of this study over Dick's is that in the present investigation, the similarity between stimuli varied from maximum to a point that is somewhere less than maximum. Whereas, both of Dick's conditions were less than maximum similarity.

Underwood suggests that on at least stimulus generalization, there is a possibility of rapprochement of conditioning, rote learning, and tasks which fall within the category of thinking. Underwood suggests that there may be communality among the situations producing behavior changes which fit the definitional requirements of learning. The results

of this study show that there is a significant difference in the generalization resulting from paired-associate learning and concept formation. These results suggest that the underlying processes producing behavior changes in the concept formation and paired-associate learning may not be the same.

It may be concluded that this study seems to uphold the hypothesis proposed by Dick and to introduce some doubt on Underwood's suggestion with regard to communality between generalization from paired associates and concepts.

Summary

This study was designed to test the hypothesis that generalization tendencies resulting from concept formation would be greater than those resulting from paired-associate learning. In order to test this hypothesis, forty volunteer Ss were individually trained to learning criteria by methods which fit the definitional requirements of paired-associate learning or concept formation. A generalization test was then administered immediately following the training.

The stimuli were 35 random, eight-sided forms, arranged in five sets of seven forms. Each set was composed of one randomly generated prototype and six, semi-random variations of that prototype. The variations of each prototype were obtained by varying the points on which the prototype was generated in both a plus and a minus direction. The prototypes and the five "plus" deviations of each prototype were used as training stimuli. The "minus" deviations of the prototypes were used as test stimuli. A unique nonsense syllable name was assigned to each set of stimuli.

A significant difference in generalization tendencies was found between learning methods. This difference was in favor of the concept formation group. It was concluded that the hypothesis was upheld and that concept formation does produce greater generalization tendencies than does paired-associate learning.

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